Treasurer.

Horace Jayne.

Curators.

J. Cheston Morris, Benjamin Smith Lyman, Henry Pettit.

Councillors to serve for three years.

Richard Wood, Henry Carey Baird, Samuel G. Dixon, Joseph G. Rosengarten.

The Society was adjourned by the presiding officer.

THE OSTEOLOGY OF THE CUCKOOS.

[Coccyges.]

(Plates I and II.)

BY DR. R. W. SHUFELDT.

(*Read January 4, 1901.*)

Introduction.

My first paper evidencing any special interest in the structure of the Cuckoos was published in *The Ibis*, of London, July 1, 1885 (pp. 286–288), and was entitled "On the Coloration in Life of the Naked Skin-tracts on the Head of Geococcyx californianus," being illustrated with a fine colored figure of the head of the Californian Road-runner, natural size. In this paper the osteology of *Geococcyx* was not touched upon, it merely calling attention for the first time in science to the brilliant scarlet coloration of the naked areas on the back of the head of the bird in question. This paper was, however, soon followed by another in January, 1886, in which a complete account of the skeleton of *Geococcyx californianus* was given, illustrated by three plates, devoted to figuring the skull from three or four points of view, and also all the other bones in the osseous system of this species. It was published in *The Journal of Anatomy and Physiology* (London and Edinburgh, Vol. xx, Part II, pp. 244–266, Pls. VII–IX). As in the case of a few others, this memoir is referred to again below, and is indeed, without its figures, substantially reproduced in the present work, after having been thoroughly revised (and augmented slightly) by myself. Al-

though the figures to this memoir were not, as I say, here reproduced, I have, nevertheless, devoted one of my present plates to the bones of *Geococcyx*, giving four of the skull, one of which has never been published before; a ventral view of the pelvis published for the first time; and pelvic limb-bones of a subadult individual to illustrate remarks in the text. These bones are given for the purposes of comparison and reference.

Again in the same journal last quoted I printed in October, 1886, a brief "Osteological Note upon the Young of Geococcyx californianus (Lond. Vol. i, Pt. i, pp. 101–102), in which certain points of interest referable to the tibio-tarsus were dwelt upon.

A very general account of the entire structure of this species I published still later on in the *Proceedings of the Zoölogical Society of London* (Apr. 1, 1887. Pt. iv, pp. 466–491, Pls. XLII–XLV, 2 wcc. in text)—that is, apart from a treatment of the skeleton, as that had already been published, as stated above. The figures to this memoir had been submitted the size of life, but were subsequently reduced, a fact that was noted, or rather record made of in *The Auk* later on (*Geococcyx californianus*—A correction, Vol. iv, No. 3, July, 1887, pp. 254, 255). After this date I referred to the anatomy of the *Coccyges* in various places and in different publications, but gave no extensive work devoted exclusively to a study of their osteology as a whole.

In the present memoir I have brought together all the material illustrating the osteology of the Cuckoos at my command, and have described and compared it. I am indebted to Mr. Lucas for the loan of some of this material from the collections of the United States National Museum, where, unfortunately, they are very poor in Cuckoo skeletons. The balance of what I have, has been either collected by myself or for me by others.

Representatives of the Suborder Coccyges are found in many parts of the world, and Cuckoos present us, in the forms already known to science, with a list of some one hundred and sixty or more species, exhibiting great variation in structure, size, coloration and, indeed, general morphology. Their peculiar habits of nidification and other eccentricities that characterize them are known to ornithologists and ornithotomists alike, and need not be reviewed here in a work upon their osteology. Some Cuckoos, the "Tree Cuckoos" so-called, are arboreal types, rarely alighting upon the ground,

while others, such as our Californian "Road Runner," are naturally terrestrial habitues, and only occasionally alight in the larger trees. Both Africa and Madagascar contain wonderfully interesting Cuckoos, and other birds so closely related, that by some systematists they have been associated with them.

Our own United States avifauna offers a number of some very interesting species of the *Cuculidæ*, and these will be osteologically treated in this memoir, and it is hoped that such characters as their skeletons present may be eventually useful when our material in the museums admits of a more extended morphological and taxonomial study of the entire family.

In lower California and Texas we have *Crotaphaga sulcirostris*, and its ally *C. ani* in southern Florida. I have, thanks to Mr. Lucas, of the U. S. National Museum, some material illustrating the skeletons of both of these types. Through the southern parts of southwestern United States we also find *Geococcyx californianus*, —a large and interesting species of Ground Cuckoo. This species, as stated above in my INTRODUCTION, I chose several years ago, to present a paper upon its osteology, and it was published with three Plates in the *Journal of Anatomy* of London. Finally, we have several species of those typically American Cuckoos of the subfamily *Coccyginæ*. They include the true Tree-cuckoos of the genus *Coccygus*, and I have a number of skeletons of them, illustrating both adult and nestling forms. For one good skeleton of an adult, I am indebted to Dr. W. S. Strode, of Bernadotte, and to my son for an alcoholic nestling of *Coccygus americanus*.

As a group, Huxley considered that the *Coccygomorphæ* occupied the central position of his Desmognathous division, and in a subdivision of them (*b*) he included the *Musophagidæ*, *Cuculidæ*, *Bucconidæ*, *Rhamphastidæ*, *Capitonidæ*, and *Galbulidæ*, adding upon another page that "Among the *Cuculidæ*, *Cuculus canorus* is devoid of basipterygoids; the palatines are rounded off posterio-externally; the internasal septum is well ossified and unites with the maxillo-palatines."

"In *Geococcyx* the principle of construction is quite the same; but the postero-external angles of the palatines are distinctly indicated, and the beak is produced into an elongated triangular form. A slight oblique ridge marks off the flat surface of the maxillary process of the palatine from the excavated body of the bone." (P. Z. S., 1867, pp. 444 and 466.)

Professor Max Fürbringer makes a suborder Coccygiformes, a division of his Order CORACORNITHES, and in it divides the genus *Coccyges* into the two families *Musophagidæ* and *Cuculidæ*, the latter containing all the Cuckoos.[1]

As our knowledge of the morphology of the group now under consideration becomes more intimate, the general tendency is to withdraw from its many species, indeed sometimes an entire family or more, of birds that in former times were considered to be quite typically coccygine in character. It was Sclater who finally removed the *Trogones* from the group, and in due time, I am confident the *Coccyges* will be fully as well circumscribed as either the *Pici* or the *Psittaci*.

Several years ago, Coues still adhered to the old "polymorphic group," the Order PICARIÆ, and divided it into three groups, viz.: the *Cypseliformes*, the *Cuculiformes*, and the *Piciformes*.[2] Of the

[1] "FÜRBRINGER, MAX, *Untersuchungen zu Morphologie und Systematik der Vögel* (1888), and on page 1553 of this work he says, "Mit den ektamphibolen *Musophagidæ* und den zygodactylen *Cuculidæ* beginnt die Reihe der Baumvögel (Coracornithes s. Dendronithes). Beide sind mit einander ziemlich nahe verwandt und bilden die G. COCCYGES und So. COCCYGIFORMES, welche trotz einzelner specieller und ziemlich hoher Differenzirungen der Cuculidæ im Grossen und Ganzen doch nur eine mittlere Entwickelungshöhe unter den Coracornithes erreicht und von allen Unterordnungen derselben von den Galliformes am wenigsten absteht. Die kleine, enggeschlossene und jetzt auf die aethiopische Region beschränkte Familie der *Musophagidæ* repraesentirt den primitiveren und in der Abnahme begriffenen Typus; in tertiärer Zeit war sie vielleicht auch über Europa und noch weiter ausgedehnt (Necrornis?) Die nahezu kosmopolitischen *Cuculidæ* sind weit umfangreicher und mannigfaltiger ausgebildet und in der Hauptsache höher differenzirt; von ihren Unterfamilien dürften wohl im Grossen und Ganzen die Phoenicophainæ den tiefsten, die Crotophaginæ den höchsten Platz einnehmen. Ihre paleontologische Kenntniss ist allzu mangelhaft, um systematische Aufklärungen zu gelben.

"In einer nur mässigen Entfurnung von den *Cuculidæ* scheint die kleine Familie der neotropischen *Bucconidæ* zu stehen; der Mangel eigener Beobachtungen und die bisherige Unvollständigkeit in der morphologischen Untersuchung irgend eines Vertreters derselben machen mir eine sichere Entscheidung hinsichlich ihrer systematischen Stellung vor der vermuthlich näher verwandt dieselben kehren zugleich ihr Gesicht den Pici zu, ohne aber intimere Relationen zu ihnen zu besitzen. Vorausgesetzt, dass die bisherigen Angaben über die *Bucconidæ* richtig sind, bin ich geneigt, beide Familien zu der G. GALBULÆ zu verbinden und diese als eine intermediäre Abtheilung zwischen die Coccygiformes (*Cuculidæ*) und Pico-Passeriformes (*Pici*) zu stellen."

[2] COUES, E. *Key to North American Birds*, rev. ed., 1884, p. 446.

second-named he said that they comprehended the great bulk of the Order; "in all, about fifteen families, rather more than less. They are only readily limited by exclusion of the characters of the preceding and following groups. The sternum is usually notched behind; the syringeal muscles are two pairs at most. The feet are *generally* short; the disposition of the toes varies remarkably. In the *Coliidæ*, or colies, of Africa, all the toes are turned forward. In the *Trogonidæ*, the second toe is turned backward, so the birds are zygodactyle, but in a different way from all others. Families with the feet permanently zygodactyle in the ordinary way by reversion of the fourth, or partially so, the outer toe being versatile, are—the *Cuculidæ*, or Cuckoos, with their near relatives the *Indicatoridæ* or Guide-birds of Africa; the *Rhamphastidæ*, or Toucans, confined to tropical America and distinguished by their enormous vaulted bill; the *Musophagidæ*, Plaintain-Eaters or Touracos, of Africa; the *Bucconidæ* and *Capitonidæ*, or fissirostral and scansorial Barbets of the New and chiefly of the Old World respectively; and the *Galbulidæ*, or Jacamars, of America. (The *Cuculidæ* and *Musophagidæ* are by Garrod placed together with Gallinaceous birds.) In the remaining groups, the toes have the ordinary position, but sometimes offer unusual characters in other respects. Thus in the *Alcedinidæ* (Kingfishers), and *Momotidæ* (Motmots or Sawbills), the middle and outer toes are perfectly coherent for a great distance, constituting the *syngenesious*, *syndactyle* or *anisodactyle* foot. The *Bucerotidæ*, or Hornbills, of the Old World, characterized by an immense corneous process on the bill, are relatives of the Kingfishers; so are the *Todidæ*, a group of small, brightly-colored birds of Mexico and the West Indies. Other forms, all Old World, are the *Meropidæ* or bee-eaters, the *Upupidæ* or Hoopoes, and the *Coraciidæ* or Rollers, with their allies the *Leptosomatidæ*, of Madagascar."

Garrod examined a good many Cuculine birds, and he divided the *Cuculidæ* into the *Centropodinæ* to contain the Ground Cuckoos, and the *Cuculinæ*, or True Cuckoos.[1] Several years later I examined the structure of *Geococcyx californianus*, and in the opinion I

[1] Garrod, A. H. *Collected Scientific Papers*, 1881, p. 220. This author found the *Cuculidæ* to possess the ambiens muscle, two carotids, a nude oil-gland and cæca. The *Centropodinæ* have a formula AB. XY and the *Cuculinæ*, A. XY.

then arrived at it appeared clear to me that Garrod's classification of the *Cuculidæ* was well supported.'"[1]

Nitzsch did something with the classification of the Cuckoos, using their various patterns in pterylography, but the work was only partial and in the main not quite satisfactory.[2]

In 1873 (P. Z. S., p. 578) Mr. Sharpe, of the British Museum, again attacked them, selecting for his labors the cuculine birds of the Ethiopian Region. He made two subfamilies of the forms there represented and examined, viz: (1) *Cuculinæ*, containing *Cuculus* and *Coccystes*, and (2) *Phœnicophainæ*, in which he placed *Phœnicophaës*, *Centropus*, *Coua* and others.

About twelve years later another important paper on the *Cuculidæ* appeared, being a contribution by Mr. F. E. Beddard,[3] and in it he agrees in the main with Sharpe, but makes some few but apparently justifiable changes. His opinions are deduced from a study of the muscles of the thigh, the syrinx and the pterylosis of the *Cuculidæ*. He was fortunate in being enabled to study a very large series of species representing some thirteen genera, and upon this material he divides the Family CUCULIDÆ into three Subfamilies, the *Cuculinæ*, in which our *Coccyzus* is found in group (*b*); the *Phœnicophainæ*, containing only Old World forms; and the *Centropodinæ*,

[1] SHUFELDT, R. W. *Contributions to the Anatomy of Geococcyx californianus. Proc. Zoöl. Soc. of London*, 1886, pp. 466–491, Pls. XLII–XLV. It was shown here that our United States *Cuculidæ* properly belonged to three subfamilies, the *Crotophaginæ*, or Anis, the *Centropodinæ*, or Ground Cuckoos, and the *Cuculinæ*, or True Cuckoos. Besides the paper on the Osteology of *Geococcyx*, published in the *Journal of Anatomy of London*, and referred to above, the writer has also produced two other minor contributions to the morphology of this bird—viz., one in the *Ibis* with a colored plate, showing the colored skin-tracts around the eye and back of the head (Lond., 1885, pp. 286–288, Pl. VII): and the other in the *Journal of Anatomy of London* entitled, "Osteological note upon the young of *Geococcyx californianus*" (Vol. xxi, pp. 101, 102, Figs. 1 and 2). The last-named will to some extent be incorporated in the present memoir, and both have already been cited in the Introduction above.

[2] Pterylography, English edition, p. 91.

[3] BEDDARD, F. E. *On the Structural Characters and Classification of the Cuckoos*. P. Z. S., Lond., 1885, pp. 168–187, wcc. in text. In this paper the writer points out an error formerly made by Owen (OWEN, R., Comp. Anat. of Verts., Vol. ii, p. 177), and says: "The *gall-bladder* is stated by Owen to be wanting in almost all the *Cuculidæ*. This statement is by no means correct; indeed the gall-bladder appears to be very generally present, and those cases where it is absent are the exceptions."

where we find *Geococcyx*, *Crotophaga* and *Guira* all associated in another group *b*.

To this last arrangement I very much demur, and doubt that the retention of *Geococcyx* and *Crotaphaga* in the same subfamily at all expresses the natural affinities of these forms within the family. It will be seen later that they are very distinct types of Cuckoos, in so far as they are osteologically organized. As I have already stated elsewhere, I believe the *Crotophaginæ* constitutes a distinct subfamily, and the summation of the entire morphology and a knowledge of their especial habits will go far towards supporting this arrangement.

Osteology of Geococcyx.

Of the Skull.—In *Geococcyx* we find the osseous superior mandible with a gently curved and rounded culmen, the curve increasing very modestly as it approaches the apex. This part of the skull has a broad base, being both deep and wide in the rhinal region, while on all aspects it tapers gradually to the slightly decurved tip. Its buccal surface is flat, with cultrate edges somewhat raised above the general plane behind. Posteriorly, this face is encroached upon by the palatines and maxillo-palatines. Turning to the lateral surfaces of this mandible (Pl. I, Fig. 1), we find them for the most part to be slightly convex throughout their extent; the only exception to this being seen in the depressions which are found, one over each of the scale-like projections that close the hinder two-thirds of either nostril.

These last-mentioned openings are of a subelliptical outline, placed longitudinally nearer to the edge of the beak than its culmen and just posterior to its middle. They do not directly communicate with each other, but are external apertures, in this bird, of osseous tubes, one on either side, which are produced backwards nearly to the rhinal chamber, being encased in the loose, osseous, spongy mass that almost fills the otherwise hollow superior mandible of *Geococcyx*.

In the skull freshly prepared, and before it dries, the cranio-facial hinge enjoys considerable mobility, and its position is clearly indicated by a transverse track. Mesially, this region is depressed, and may show the last sutural traces of the nasal processes of the premaxillary therein. Each nasal bone has been so completely met by the various surrounding elements that, save its hinder margin,

its boundaries are hard to define in the adult bird (Pl. I, Fig. 1). This is not the case, however, in the skull of a nestling *Geococcyx* at my hand, where the bone is easily studied. Its premaxillary process is rather long and very slender, while its two remaining projections are broad. Near its middle it is perforated by a small foramen, which we find persists throughout life and seems to correspond to a similar minute aperture found in the same locality in the skulls of certain Kingfishers (*Ceryle*). All three sides of this osseous superior mandible are more or less marked by anastomosing venations, and a few perforating foramina are always seen near its apex.

A lacrymal in *Geococcyx* is an unusually large bone, though a light one, due to its very open cancellous structure within, and its being, perhaps, pneumatic besides. Superiorly, it articulates with the frontal and nasal, principally with the last on the lateral aspect, though it departs from it some time before reaching its lowest point, where a slit-like interval is seen between the two bones. Below, its broad, rounded margin is placed obliquely, its outer and at the same time posterior end resting upon the upper side of the maxillary, while its inner and anterior end being elevated just above the superior surface of the corresponding palatine.

The posterior aspect of the lacrymal is concave from above downward, in conformity with the somewhat globular concavity of the orbit, while anteriorly it is correspondingly convex in the same direction. It lies in front of the broad, quadrilateral ethmoidal wing which overlaps it, the two forming a very complete partition between the orbit and rhinal chamber, the bone under consideration closing the outer third of the space.

The ethmoidal wing, the form of which I have just given, is pierced above, immediately beneath the frontal bone, by two elliptical foramina, the inner one being the larger, and both being vertical. They probably transmit the olfactory nerve and vessels to the rhinal space.

This "pars plana" has, like the lacrymal, also a somewhat cancellous internal structure, the plate being moderately thick. Its lower and outer margins are concave and smoothly rounded off.

The expanded anterior extremity of a maxillary is immovably wedged in between the nasal above and the posterior dentary process of the premaxillary beneath. Its rod-like extension behind forms about the anterior third of the very straight quadrato-jugal

bar. The horizontally expanded end alluded to is quite ample and may be perforated by numerous foramina. Its maxillo-palatine development will be described when speaking of the under side of the skull.

The remainder of the quadrato-jugal bar becomes gradually larger and club-shaped as it nears the quadrate bone, to rather abruptly turn inward as it reaches it, and is inserted in a vertical notch in the usual apophysis of that element, which projects directly outward to meet it (Pl. I, Fig. 2).

With respect to the quadrate, we find that its orbital process is very broad and flat, being at the same time very short. The body of the bone is also broad, while its mastoidal apophysis is twisted in a way common to many other birds, and supports at its summit two articular heads with a distinct valley between them. At the inferior aspect of the mandibular foot there are two condyles for articulation with the lower jaw. The inner and smaller of these is hemi-ellipsoidal in form, with its major axis in the same straight line that constitutes the longitudinal axis of the corresponding pterygoid. If this axis be produced the other way, it is found to be at right angles to the long axis of the other and larger facet of the mandibular foot of the quadrate. Rather a broad notch separates these two condyles from each other.

The quadrate is a thoroughly pneumatic bone, and a large foramen is always found upon its posterior aspect half way between the mastoidal head and the mandibular foot.

Both the sphenotic and mastoid processes are well developed in this bird; they are of about an equal size, the first being directed downward, and the last downward and forward. Between them, and carried well to the rear, is a sharply defined and rather deep crotaphyte fossa. It is separated from a like depression of the opposite side by an interval of one and a half centimetres. These crotaphyte fossæ are fully as well marked in *Geococcyx* as they are in many of the *Laridæ*, and better than they are in some members of that group of birds, better, for instance, than they are in *Larus philadelphia*.

Owing to the great breadth of the frontals, the orbit is completely sheltered above by an arching roof, the outer periphery of which is concave inward and bounded by a sharp edge. This orbital vault usually shows posteriorly a few perforating foramina. The rostrum of the sphenoid is pneumatic and rounded for its entire length

beneath. It barely extends beyond the broad ethmoidal wings in front and ascends but little as it proceeds in that direction. In the nestling it is seen to be sharp-pointed anteriorly and grooved its entire length superiorly.

The inter-orbital septum is a thin partition of bone, which always possesses a considerable quadrilateral vacuity near its centre. This usually merges with the foramen for the exit of the optic nerves (Pl. I, Fig. 1), while the small foramen for the exit of the oculi-motor remains distinct.

As might be expected from what has already been said about the orbit, we find its hinder wall also very broad and generally concave forward. At its usual site a distinct, irregular foramen of some size is found for the exit of the olfactory nerve, and this branch passes forward in the living bird in a shallow channel on the inter-orbital septum beneath the frontal for its entire length, where these two elements are united. It leads to the inner and larger of the two foramina that were described above as occurring over pars plana.

Before leaving this side view of the skull it will be as well to notice the large, luniform sesamoid that occurs in the ligament that passes from the quadrato-jugal to the hinder border of the articular cup of the mandible. This sesamoid is present on both sides and in all the skulls of *Geococcyx* that I have ever had the opportunity of examining.

On the superior view of the skull we are to note the form of the bony laminæ that partially close in the external narial openings from behind; the position of the two small circular foramina beyond the cranio-facial hinge; and this fronto-lacrymal region generally. From this aspect we also see the small foramina that pierce on either side the orbital roofs behind. Mesially, and between these latter, a shallow, longitudinal groove marks the cranial vault. Posterior to this again we find a smooth, globular and ample parietal region. The crotaphyte fossæ may likewise be discerned from this upper aspect and a glimpse obtained of the supra-occipital prominence. Here, too, may also be seen the manner in which the quadrato-jugals articulate with the quadrates.

Viewing the skull of *Geococcyx* from beneath, we find, anteriorly, the broad, flat surface, already spoken of, which forms the lower face of the superior mandible (Pl. I, Fig. 2).

Following this back we come to an elongated median vacuity,

that separates the anterior terminations of the maxillo-palatines. This aperture has irregular, jagged edges, and through it we may see some of the open, spongy bone tissue that partially fills the hinder portion of the core of the superior mandible. At the sides, the posterior processes of the dentary parts of the premaxillary overlap the maxillaries. They are long and triangular, with their apices to the rear.

Returning to the maxillo-palatines, we find them to be, upon this aspect of the skull, two very sizable, elongated, subcylindrical masses, composed of an internal spongy tissue, but encased in an outer covering of an extremely thin layer of compact tissue. They lie parallel to each other and to the median plane, nearly filling the interpalatine space. Anteriorly, they are separated by the vacuity already described, while behind, their free and rounded extremities slightly diverge from each other, they being in contact in the median line for the middle thirds of their lengths (Pl. I, Fig. 2). From their upper sides is developed a mass of open spongy tissue; this is continuous with a similar structure that is found within the superior mandible; it reaches out, on either side, to abut against the inner surfaces of the nasals; it joins the horizontal plates of the maxillaries, and finally supports a median vertical plate of bone that stands just beyond the rhinal chamber proper, this latter space being free from its encroachment, as it is from any development of the ethmoid behind, beyond its lateral wings.

The anterior half of either palatine is quite a broad, flat, horizontal plate, the distal end of which indistinguishably fuses, and is directly continuous with the horizontal portion of the premaxillary. To its inner side also, in this locality, it completely anchyloses with the corresponding maxillo-palatine (Pl. I, Fig. 2). For the most part, however, its inner and outer edges are free, not coming in contact by the inner one with the maxillo-palatine, though it is parallel to it and separated by an extremely narrow interval, while its outer one neither touches the lacrymal nor the maxillary, but occupies a plane inferior to both.

The posterior half of a palatine also lies mainly in the horizontal plane, but its under surface is a concave one, and its upper correspondingly convex. Its outer free edge, directly continuous with the outer edge of the anterior half of the bone, sweeps by a gentle curve round the "postero-external angle" of the palatine to its head. Huxley was in error when he stated (P. Z. S., 1867, p.

444) that these angles in *Geococcyx* "are distinctly indicated." They are rounded, as he so well figures them for *Cuculus canorus*.[1]

The inner free edge of the bone extends from the head to the apex of a small pointed process in front. For nearly its entire length it is parallel to the corresponding edge of the palatine of the opposite side, from which it is separated by an interval of something like a millimetre or rather more. From this edge the surface curves outward and backward, forming the "ascending process" of the palatine. This terminates in another longitudinal straight margin, which is applied to the corresponding one of the opposite palatine, and both unite to form the usual groove at their upper aspects for the rostrum of the sphenoid. These latter opposed edges also extend from the palatine heads, likewise in contact mesially, to a common anterior process. This latter is nearly opposite the anterior end of the rostrum, and from its extremity in front projects a free, needle-like and rudimentary vomer, of some four millimetres in length. It does not come in contact with the maxillo-palatines, but lies above the interval formed by their slightly diverging posterior extremities, and is freely articulated with the palatines at the points from which it springs, and in the manner described. This diminutive vomer is equally well developed in both my specimens of *Geococcyx*.

Careful search was made in all of my specimens for an *ossiculum lacrymo-palatinum* (*os uncinatum*), but failed to reveal the presence of any such ossicle. This diminutive bone was first described by Brandt, and, as is well known, occupies at least two positions in the skull. In certain Albatrosses (*Diomedea brachyura*) it exists as a delicate styliform bar connecting the descending limb of the lacrymal bone with the upper surface of the corresponding palatine. Other birds have it attached to the infero-external angle of the lacrymal, where it may project freely backward, or lie along the upper surface of the maxillary bar beneath it. Its position in the Parrots is described in my memoir on the osteology of *Conurus*.

According to Forbes, "it also occurs in forms so different from these [Albatrosses] as the Musophagidæ, many Cuculidæ, *Chunga*

[1] In this connection compare what I have quoted, in an early paragraph of this memoir, from Professor Huxley with a footnote which appeared in my "Osteology of Geococcyx" (*Journ. of Anat.*, London, p. 247), cited above. It must be that the skull of *Geococcyx* which Professor Huxley examined was either an imperfect or broken one.

and *Cariama*, as well as in some Laridæ and Alcidæ, so that its presence is obviously of no particular taxonomic value." (*Coll. Scientif. Mem.*, p. 415.)

A pterygoid is a nearly straight and slender bone, and shows not the slightest evidence of the development on its shaft of an apophysis, and indeed there is no necessity for such, as the basipterygoidal processes are entirely absent in this bird; and the pterygoids when *in situ* occupy a lower plane than the basitemporal region, as well as being at some distance in front of it.

These bones articulate with each other anteriorly and with the opposed palatines; from this point they diverge at an angle of about 85°, each to meet the usual facet upon the corresponding quadrate at the base of the inner and smaller condyle on that bone.

The basi-temporal region is elevated above the prominent and raised boundaries of the auricular apertures; it is narrow and smooth and lies for the most part in the horizontal plane. In front, it presents for our examination a thin tip of bone, arching over the common aperture of the Eustachian tubes.

Beyond this it contracts to form the sphenoidal rostrum, a considerable portion of which is unoccupied before we reach the pterygoidal heads. This allows these bones not a little backward play in the recent specimen, an action which is quite possible from the more than ordinary mobility enjoyed on the part of the craniofacial hinge.

Either external auricular couch is a capacious fossa, well defined by a raised and bounding thin wall of bone, with its free edge curled in all round. At the base of either of these fossæ we see strong osseous trabeculæ, converging to a point near the centre to support the double concave facet for the mastoidal head of the quadrate. These stand between the Eustachian entrance and the passage to the middle ear.

If the plane of the basis cranii be produced posteriorly, and the plane of the occiput and foramen magnum extended to meet it, we find the latter makes an angle with the first-mentioned plane of about 48°, while the long axis of the fairly well-developed supra-occipital prominence would be perpendicular to it. In form the foramen magnum is broadly cordate with its apex above; the occipital condyle at its lower margin is small, sessile and hemispherical in outline, being so placed as to encroach upon the foraminal periphery for about one-third of the condylar arc.

Points of interest within the brain-case are seen in the presence of a strongly marked longitudinal sinus and the unusual thickness of the walls of the sella turcica; its fossa, though deep, being quite small, while at its base we find a double entrance for the carotids.

As a whole the skull of *Geococcyx* is a delicate and a very light structure for its size, air gaining thorough access to most of its parts.

The mandible (Pl. I, Figs. 1 and 3), seen from superior aspect, has the typical V-shaped form, with an extensive symphysis, which is scooped out longitudinally above. Either ramus is not deep in the vertical direction, while its upper and lower margins are prominent and rounded, the former, however, becoming sharp as it approaches the symphysis, which condition is sustained to the mandibular apex.

The ramal vacuity is large and occupies its most usual site; in outline it is an elongated ellipse, but its anterior third is encroached upon by a thin plate developed on the part of the dentary element.

An articular end is considerably concave above and presents two facets for the condyles of the quadrate; its inturned process is much tipped up, while the usual pneumatic foramen is seen near its apex. Below, its convexity conforms with the convexity of the articular excavation at its upper side, and its angle behind is obliquely truncate from above downward in the forward direction.

Beyond an articular end on the superior ramal border, we find, on either side, the coronoid process but feebly developed and single.

When the osseous mandible is articulated *in situ* with the remainder of the skull its tip does not extend quite so far forward as does the apex of the superior osseous beak, a condition present in the skulls of most *Coracomorphæ* and other groups.

In the hyoidean apparatus we find fully the anterior two-thirds of the glosso-hyal represented by a thin strip of cartilage, while behind, where it ossifies in front, the usual median foramen is seen, having an elliptical outline. Posterior to this, on either side, the strongly marked cerato-hyals project outward and backward.

First and second basi-branchials do not anchylose with each other, the former being short and thick, the latter about half as long again and tipped off behind with cartilage.

The elements of the thyro-hyals are long and slender; they like-

wise terminate in cartilaginous tips and curve up behind the skull in the manner most usual among birds.

There are about twelve osseous sclerotal platelets in the circlet found in either eyeball. They present us with nothing worthy of especial remark, seeming to possess their most usual ornithic characters.

It may be as well to add here a few words describing the ossifications of the trachea, and we find for the entire length of this subcylindrical tube the osseous rings which compose it fail to meet in the longitudinal median line posteriorly.

The interval thus formed, which is not very great, is occupied by a thin membrane which is continuous with the internal tympaniform membrane of the lower larynx. As to shape, the trachea diminishes in calibre gradually from above downward, and nowhere in its continuity does it present any enlargements or dilatations.

This does not apply exactly to the bronchial bifurcations, for each one of them shows a disposition to swell just before arriving at the contracted parts of these tubes, where they impinge upon the lung tissue.

We may reckon either of these bifurcations as being partially surrounded by thirteen semirings. Of course in this bird, as I say, the entire trachea may be regarded as having only semirings, but had the usual number of these united behind there would still have remained the thirteen semirings to each bronchial tube. An osseous pessulus is not present in *Geococcyx*, and the internal tympaniform membrane is quite extensive. There does not even seem to be any thickening of this membrane in our subject where this bony little bridge is located in those birds where it exists. (For figures of the trachea of *Geococcyx* see my memoir in the P. Z. S. cited above.)

Of the Remainder of the Axial Skeleton—The Vertebral Column.—This column presents us with eighteen movable vertebræ before we arrive at the consolidated pelvic sacrum. This latter contains eleven more segments, thoroughly united together and firmly joined to the iliac bones. Finally, we find five vertebræ and a large pygostyle in the skeleton of the tail of *Geococcyx*.

In the cervical region we pass twelve vertebræ before we come to the first one of the series that bears a pair of free ribs, the thirteenth and fourteenth both possessing these appendages, and in both they are well developed, though not reaching the sternum, through the intervention of costal ribs. The pair on the fourteenth vertebra

has the epipleural processes fully as large as they are in the dorsal series; they are absent entirely, however, on the first pair of free ribs.

Returning to the atlas we find this segment rather delicately constructed, though in form it is quite like what we find in other groups of birds, the *Passeres* for instance. Its neural arch is narrow antero-posteriorly, though the canal is capacious. A perforation is seen at the base of the articular cup for the occipital condyle, which cuts through the superior margin of this little concavity. The centrum is small and does not develop anything that might be called an hypapophysis. On the axis vertebra we note the presence of a low, tuberous, neural spine, occupying the entire central portion of the arch, while posteriorly on the under side of the centrum a feebly pronounced hypapophysis is seen. The odontoid apophysis is small and short as compared with other features of this vertebra, a fact no doubt due to the lack of depth in the atlas. At either side of the centrum we observe a delicate and vertical spicula of bone which completely arches over the vertebral vessels, constituting the last remnants of the lateral canal at this extremity of the column. This condition is often met with among the *Anatidæ* in the axis vertebra of those birds.

The postzygapophyses are directed backward and outward, and are very powerfully developed, more so than in any of the first nine or ten vertebræ of this portion of the column. The facets they bear for articulation with the extremities of the prezygapophyses of the third segment are at their under side about the middle. On the third and fourth vertebræ we also find a low neural spine placed at the centre of either bone, while the hypapophysis is becoming reduced in these segments, to disappear entirely in the fifth vertebra. These vertebræ, as in so many of the class, have their zygapophysial processes joined by a spanning lamina of bone, which in either case and on either side is pierced near its middle by a small elliptical foramen of the greater size in the fourth vertebra.

The lateral canals occupy rather more than the anterior halves of the sides of the centra, and the processes that project from the under aspects of their free margins behind are short, and each is separated by a considerable interval from its fellow of the opposite side. This great inferior width of the cervical vertebra is a characteristic feature of these segments in *Geococcyx*, and is well sustained throughout the series until we come to the free rib-bearing

ones, when a gradual contraction takes place as we pass into the dorsal region. But even here the segments are comparatively broader in their transverse diameters than we often find them.

In the fifth vertebra the neural spine is placed further forward on the bone, but is very small; it is absent in the sixth, or only faintly indicated, and it does not appear in the series again until we find it as a pronounced crest on the fifteenth segment. Sometimes, however, a low, tuberous elevation marks its site in the few ultimate cervicals.

Prezygapophyses in the fifth vertebra stand almost directly outward, while the postzygapophyses very prominently point to the rear. Little modification takes place in the former of these processes as we examine the succeeding vertebræ, their general direction remaining about the same, but the articular facets they bear face more and more toward the median plane as we proceed backward. With the postzygapophyses, however, the case is otherwise, for as we descend the cervical series we find these become gradually shorter and stouter with a wider divergence, while their facets, from facing downward and outward, come to look almost directly downward.

We find strongly marked metapophyses surmounting the bases of the postzygapophyses in the sixth to the ninth cervical vertebræ inclusive; after that they disappear, and are but feebly reproduced in the dorsals, where they occur on the superior aspects of the ends of the transverse processes.

On the fifth cervical vertebra the lateral canal is at its forward part, appropriating about the anterior moiety of the entire centrum. Its outer wall may show a slight perforation, while the parapophyses which project from it behind are on either side a short and needle-like spine. As we pass down the series this perforation becomes larger and larger, until in the tenth vertebra it has broken through the hinder free margin of the lateral canal and disappeared, leaving in the segment only a shorter passage and a deep concave notch indicating its site. *Pari passu* with this change, the parapophyses and pleurapophyses pass through the usual evolution in that direction, to result in the perfect and free pair of ribs found in the thirteenth vertebra. Faint beginnings of a carotid canal are also seen in the fifth vertebra, in the presence of a shallow excavation at the anterior end of the under side of the segment. This becomes better and better marked to include the tenth vertebra,

where this canal is moderately well protected by lateral walls, but in none of the series does it become a closed passage as in some other birds. In the eleventh vertebra its place is taken by a strong, single and median hypapophysis.

This last becomes faintly tricornate in the twelfth vertebra, markedly so in the next segment; the three prongs springing from a common pedicle in the fourteenth, which pedicle is lengthened in the fifteenth; still larger but without terminal prongs in the sixteenth vertebra, to be entirely absent in the succeeding segment and the rest of the column.

In the atlas the neural canal is capacious and transversely elliptical. From this vertebra it gradually changes its form and contracts in calibre, until in the fifth vertebra we find it nearly cylindrical in shape and much reduced in capacity.

Passing down the series it gradually changes for a second time, so that in the eleventh vertebra it is again found to be large and transversely elliptical. This form it retains through the dorsal series, though once more reduced in calibre.

In the tail vertebræ it is at first triangular with apex above, to become a vertical slit as it enters the pygostyle.

The fifteenth, sixteenth, seventeenth and eighteenth vertebræ of the column in *Geococcyx* support ribs that meet to articulate with costal ribs below.

These ribs are broad above, but become more and more rod-like as they near their hæmapophysial articulations. The first three pair of the series bear large epipleural processes, which are always anchylosed to the rib upon which they appear. These three also have costal ribs connecting them with the sternum; this I believe to be as small a number of the latter present in any living bird—*i.e.*, only three hæmapophyses articulating with either costal border of the sternum. The last pair of ribs, or those coming from the eighteenth vertebræ, never have epipleural processes, and their costal ribs do not reach the sternum.

With respect to the four vertebræ that bear the ribs, we find that they present all the characters of the dorsals as found among Aves generally. The neural spines are lofty and quadrilateral in outline, each having its superior rim capped off with a vertically flattened tablet of bone. The diapophyses are rather broad, and project directly outward from the sides of the vertebræ, having the ribs articulating with them and the centra in the usual way. Very

close interlocking is evidenced among these four dorsal segments, and the post- and prezygapophyses are no longer than is necessary to afford the proper amount of surface for their respective articular facets. Anteriorly, these face upward and inward, precisely the reverse being the case with those found on the postzygapophyses.

So far as we have examined the vertebral column, the articulation which obtains among the centra is upon the *heterocœlous* plan—*i.e*, the anterior facet is concave from side to side, convex from above downward, precisely the reverse condition being present in the posterior facet. All these vertebræ, as well as both kinds of ribs, are eminently pneumatic, groups of foramina occurring at the usual sites in these bones.

The Pelvis (Pl. I, Fig. 4).—From its singularly unique form the pelvis of *Geococcyx* has attracted the attention of a number of anatomists. Owen speaks of the ilium as forming behind "a prominent ridge in most birds, which generally overhangs the outer surface; in *Geococcyx* to a remarkable extent, like a wide penthouse, producing a deep concavity in the outer and back part of the ilium, where it coalesces with the ischium." [1]

Marsh, in his classical work upon the *Odontornithes*, again calls attention to the same thing, and points out other particulars in connection with it, making admirable comparisons with the pelves of *Reptilia*, *Tinamus* and other forms.[2]

Strange to relate, the only other living American bird, so far as I have examined, that possesses a pelvis anything like the one we find in *Geococcyx* is the common Sora Rail (*Porzana carolina*).

This bird not only has either ilium forming the peculiar outward-curling crest behind, but has also the propubis well marked and identically the same style assumed by the anterior portions of the ilium, *i.e.*, a deeply concave inner margin, with the sacral crista mounting above it and not coming in contact with the same.

Viewing the pelvis of *Geococcyx* from above, we are to notice the condition just alluded to as well as the raised anterior emargina-

[1] *Anat. of Verts.*, Vol. ii. p. 34, London, 1866.

[2] Marsh, O. C., *Odontornithes*, pp. 70–73, Figs. 16–20, Washington Government Printing Office, 1880. There certainly can be nothing that advances our knowledge of the exact origin of birds more certainly than the constant comparison of recent forms with the material palæontology has thus far been enabled to supply us—not a great deal as yet. Prof. Marsh never seemed to allow such an opportunity to escape him.

tions of these ilia, with the processes that project from their middle points. As already hinted, the ilio-neural canals are here open grooves, and the neural crest of the sacrum stands between them as a lofty dividing wall, with much thickened superior border. This latter is distinctly marked for the entire length of the sacrum, otherwise the individualization of the vertebræ composing this part of the bone is not very distinct, as few foramina are to be found between their diapophyses until we reach the last one, where regularly occurs a large pair, throwing the ultimate urosacral into bold relief.

Upon the lateral aspect of this pelvis, we not only gain a better view of the largely developed propubis and the strangely formed hinder portion of the ilium, but we are also enabled to get a glimpse of the rather small subcircular ischiac foramen, with the reniform antitrochanter in front of it. This latter faces almost directly forward and only slightly downward, and less so outward. Beyond this again is the acetabulum, with the circular perforation at its base, the postero-superior arc of which merges with the periphery of the outer cotyloid ring at the base of the antitrochanter, while directly opposite this point the arces of these two circles are far apart, and an excavation occupies the intervening space. This grows less, of course, as we proceed either way toward the base of the antitrochanter, where, as I have said, the inner and outer rings are tangent to each other.

The elliptical obturator foramen occupies its usual position, and so close together are the postpubis and ischium that an exceedingly narrow strait leads from this vacuity into the obturator space, a long narrow interval between the last two mentioned bones. At the centre of the triangular area among these three apertures at the side of this pelvis, is found a group of small pnuematic foramina which assist in admitting the air into the substance of this light and thoroughly aerated bone.

The Caudal Vertebræ and Pygostyle.—As already stated above, the caudal vertebræ are five in number (Plate I, Fig. 4). They are chiefly noted for their high and prominent neural spines, the two loftiest being seen in the third and fourth vertebræ. The diapophyses grow longer and more spreading as we proceed in the direction of the pygostle, the last segment possessing them longer than any of the others. We find in the third caudal vertebra a small anchylosed chevron bone, which slightly overlaps the bone in front of it.

This apophysis is very strongly developed in the last two vertebræ, where it is also anchylosed to the centra, is bifid, and hooks well forward to overlap the preceding centrum in either case. Each one of these bones is pierced by pnuematic foramina in a number of places, as is also the terminal coccygeal vomer.

This latter bone has an oblong irregular figure, with its posterior margin considerably thickened, the others being cultrate. The neural canal is continued into it for some little distance, its passage being denoted on the sides of the bone by a longitudinal smooth elevation, which gradually tapers away to the postero-superior angle.

Of the Sternum and Pectoral Arch.—The sternum of *Geococcyx* is a thoroughly pnuematic bone, but air does not gain access to any of the shoulder-girdle elements.

In the case of the former, foramina are chiefly found in the concavities among the hæmapophysial facets on the costal borders. A few scattered ones may be seen in the median line upon the dorsal surface. The number of these latter vary in different specimens.

The "Road Runner" has a two-notched sternum, which gives rise to a pair of flaring xiphoidal processes on either side. Its carina is fairly well developed and moderately deep only. It extends the entire length of the bone, and is marked upon the upper side of its projecting carinal angle by a roughened facet for articulation with the hypocleidium of the furculum.

Osseous welts are raised upon its sides to facilitate muscular attachment, and these, in some specimens, extend on to the ventral aspect of the body. The inferior border of the keel is somewhat thickened.

In front of the sternum a peg-like manubrium projects out, the lower margin of which is longitudinally marked by a sharpened crest. Below this, the perpendicular anterior border of the keel is vertically concave, and this inferior manubrial crest is carried into the excavation as a median raised line.

Either costal border is very short, having but three facets upon it, and these are usually close together. In front of them, on either side, a prominent costal process is reared, constituting one of the most striking features in this part of the skeleton of *Geococcyx*.

The thoracic aspect of the sternum is very much concaved, the ventral side being correspondingly convex. Here on this latter we notice well-marked muscular lines, one on either side, commencing

at the outer termination of a coracoidal groove, and running backward to a point about opposite the middle of the keel.

The coracoidal grooves do not meet at the manubrial base in the median line, and each one is characterized as being a deep transverse notch, with upper and lower lips of projecting bone and extending laterally only so far as the inner or anterior limit of the base of the corresponding costal process. My former memoir in the *Journal of Anatomy* gives figures of the sternum of *Geococcyx*. With respect to the pectoral arch, I find a coracoid to be, comparatively speaking, an unusually long bone; its sternal or lower border extends beyond the facet proper, in order to fit into the coracoidal groove of the sternum. This end of the coracoid is not as much expanded as we find it in some birds, but, on the other hand, like many of the Class, its outer angle is produced and bent upward as a projecting process.

The shaft is long and cylindrical, being marked down its posterior and lateral aspects by muscular lines.

At the superior, or really anterior extremity of this bone we find several noteworthy and interesting characters. Its scapular process is very long, and compressed from side to side. This apophysis reaches forward, and by its slightly dilated extremity articulates with a vertically concave notch in the lower part of the head of the corresponding clavicle.

Another meeting between these two bones takes place above, and this is effected by the summit of the coracoid curving inward toward the median plane, to articulate with a considerable facet found at the highest point of the clavicular head.

These two articulations between the furculum and the coracoid completely close the tendinal canal, even without the assistance of the scapular behind, though this latter bone materially aids in increasing the actual length of this tendinal passage, by closing up the posterior gap.

The os furcula has a form about intermediate between the usual U- and V-shapes of the bone. Regarding it from a lateral aspect, the actual form of one of its transversely compressed heads can be better appreciated, as well as its method of articulation with the other bones of the girdle. This part of the skeleton of *Geococcyx* has all been figured in my former memoir on its osteology in the *Journal af Anatomy*.

Below it is flattened in the antero-posterior direction, and termin-

ates in an elongated hypocleidium. This latter articulates when the arch is *in situ* with the carinal angle of the sternum, in the manner described in a foregoing paragraph.

A scapula assists to form the glenoid cavity in the usual way, contributing about half the surface to that humeral socket. Its clavicular process reaches far forward, to make an extensive articulation with the head of the furculum, when the bones are in the position they assume in life. It also rests further forward upon the scapula process of the coracoid than is usually seen among birds. Sometimes we find the posterior third of the long, narrow blade of this bone bent down more abruptly than in the specimen I have figured in my former memoir, and its end is always rounded off, rather than being truncated, as is commonly the condition in Aves.

At the outer and back part of the shoulder-joint in the adult *Geococcyx* occurs usually a very minute sesamoid, known as the os humero scapulare, and I am led to believe that small sesamoids may yet be found in other of the tendons of the pectoral extremity in this region.

Of the Appendicular Skeleton. The Pectoral Limb.—Pneumaticity is extended only to the bone of the brachium in this limb, the hollow shafts of the other long bones being charged with medullary substance.

The humeral shaft is much bowed, and in such a manner as to be convex along its radial border and concave upon the opposite side, which concavity is more apparent owing to the prominence of the ulnar crest and the peculiar projection of the distal extremity in the continuity of this curve.

In form the shaft is nearly cylindrical and almost entirely devoid of muscular lines.

At the proximal end, a well-marked valley occurs between the ulnar crest and the spindleform humeral head. The former has barely any pneumatic fossa at its base, the circular foramen there found being nearly flush with the general surface of the bone. On the opposite aspect we find a short though prominent radial crest, which makes no pretence to extend its lamelliform plate down the shaft, as we often find to be the case in birds.

The distal extremity of this bone presents for examination the usual oblique and ulnar tubercle, while, as already alluded to, the ulnar condyle of this end is much produced and very prominent.

The anconal aspect immediately above the trochlea is flat and

smooth, the opposite side showing a broad, shallow groove for the guidance of the tendons to the antibrachium. A fairly well developed "ectocondyloid tubercle" is seen at its usual site, on the radial border of the shaft just above the oblique trochlea.

Following the example of the humerus, we find the comparatively short radius and ulna very much bowed along the continuity of their shafts. This gives rise to a broad spindle-shaped interosseous space, the two bones only coming in contact at their distal and proximal extremities when articulated.

The radius is not nearly so much bent as the other bone of the antibrachium, and presents nothing peculiar about it. On the other hand, the ulna, with its greatly curved shaft, its prominent row of secondary papillæ and its well-developed olecranon, is quite a striking bone beside it.

Composing the elements of the carpus, the two usual free segments are seen; of these, the radiale has pretty much the same form as it assumes among birds generally, while the ulnare takes on an entirely different shape. It does not develop the two limbs or processes that straddle the proximal extremity of the carpo-metacarpus when the bones are *in situ*, as in the vast majority of the Class, but is simply a bar of bone, with one end enlarged and bearing at its summit an articular facet for the ulna.

The carpo-metacarpus is chiefly interesting for its peculiarly formed mid-metacarpal. This is uncommonly broad at its proximal end and curiously twisted as it descends to anchylose with the lower end of the index metacarpal, or main shaft of this compound bone. So far as I have been enabled to discover, the phalanx of pollex-digit does not bear a terminal claw, and the bone has the usual form as seen in most birds. Nothing of note distinguishes the two phalanges of the index digit, while the small phalanx of the last finger develops, at the middle point of its hinder margin, a curious little upturned spur.

Of the Pelvic Limb.—As in the pectoral extremity, the proximal long bone of this limb, the femur, is the only one in it that enjoys a pneumatic condition. The site of the foramen that admits the air to its hollow shaft is, however, quite unique, being upon the posterior aspect of the bone, between the trochanter and head, instead of on the anterior side, as usual, below the trochanter.

This latter feature is not elevated above the articular surface at the summit, and the semi-globular head is, comparatively speaking,

rather small. A shallow excavation upon its upper side marks the usual point for the insertion of the round ligament.

The subcylindrical shaft faintly showing the muscular lines is considerably bent to the front, and at its distal extremity in that situation the rotular channel is well marked, the condylar ridges bounding it being about parallel to each other.

The outer and larger condyle of the two is at the same time the lower, and the fibular cleft that marks its posterior aspect is very wide and deeply sculpt, being rather more to the outer side than is usual.

Above these condyles, behind, the popliteal fossa is but moderately excavated, and a straight transverse line bounding it below divides it from the general trochlear surface.

We find in the next segment of this limb, the tibio-tarsus with a subcylindrical shaft below its fibular ridge that is slightly bent so as to be in the vertical line, somewhat convex anteriorly. The bending here though is not nearly so great as we find it to be in the humerus and femur or, to make the comparison more exact, in the ulna.

The cnemial crest of this leg-bone is but little raised above the undulating articular surface of its summit, while the pro- and ecto-cnemial ridges that develop below it are not peculiar.

Their planes are not at right angles to each other, that of the latter having its surface facing directly to the front. Neither is produced for any distance down the shaft of the bone, but they terminate rather abruptly upon it; the procnemial ridge terminates at a point about opposite the superior end of the fibular ridge on the other side of the shaft.

At the distal extremity of the tibio-tarsus the planes of the condyles are nearly parallel to each other, and these trochlear eminences are strikingly close together in *Geococcyx*.

The intercondyloid fossa is deeply excavated in front, to become suddenly much shallower behind as well as somewhat narrower. Upon lateral view it will be seen that the general outline of either of the condyles is more circular than we usually find it in others of the Class, where a reniform pattern prevails.

Just above the condyles, on the anterior aspect, the vertical tendinal channel is spanned by the usual little oblique bridge of bone, and this is supplemented in life by a longer ligamentous one placed in front of it.

The fibula has a large head, which is produced backward beyond its shaft. This latter makes a close ligamentous articulation with the fibular ridge of the tibio-tarsus, and at some little distance below it merges into its shaft to become almost indistinguishably fused with it.

A well-developed subcordate patella, with its apex directed below, is found in the usual tendon in *Geococcyx*.

The tarso-metatarsus of the Road Runner is a longer bone than we would be led to expect, had we in our possession but the other long bones of this limb to judge from.

Its summit presents for examination the two concavities for the condyles of the tibio-tarsus, separated by the mid-tubercle. Behind this we find a short hypotarsus, showing two vertical grooves at its back and two vertical perforations through it.

The sides and front of this bone are flat, the latter for its proximal half being longitudinally grooved, deepest above, gradually becoming shallower as it descends. Posteriorly it is likewise grooved in a somewhat similar way; but here the outer wall of the groove is raised as a sharp longitudinal crest, best marked at the middle third of the shaft and gradually subsiding toward the extremities.

At the distal end we note the three usual trochleæ for the basal joints of the toes, as shown in fig. 27 of my former memoir; however, in this zygodactyle bird the outer one of these is extended to the rear in such a manner as to allow the fourth toe to articulate in that direction.

Of these trochleæ the middle one is much the largest and is placed the lowest down; it is the only one of the three that shows the distinct median groove. The trochlea for the fourth toe is much elevated, while the inner one holds about a mid-position in this respect.

A well-developed accessory metatarsal, slung by a ligament in the usual way, is found between the shaft and the basal joint of the hallux. The perforating foramen for the passage of the anterior tibial artery is small and inconspicuous, being at the same time quite low down on the shaft.

The joints of these podal digits are harmoniously proportioned, both as regards size and comparative length. Beyond being typically zygodactyle, they offer nothing of particular note.

Before reducing my specimens to skeletons I failed to make any

special examinations as to the condition of the ossifications of the columella auris in the adult *Geococcyx*. I find, however, among other normal ossifications in this type some twelve or thirteen sclerotal plates in either eye, overlapping each other in a somewhat irregular manner. As in certain other birds, some of the tendons of the pelvic limb in old individuals of this Cuckoo are converted into bone, and small sesamoids may be found about the proximal extremities of the basal joints in the soles of the feet. The entire skeleton of the pelvic limb for *Geococcyx* is figured in my former memoir in the *Journal of Anatomy*.

Osteological Note Upon the Young of Geococcyx californianus.

My collection contains the skeleton of the nestling of the Cuckoo now under consideration, secured at the time immediately before the bird quits the nest. This skeleton is disarticulated, and, like all the skeletons of immature birds, offers a very instructive object for study.

Several years ago, as I have said in the Introduction above, I published in the London *Journal of Anatomy* (Vol. xxi, p. 101) an observation upon the tibio-tarsus of the pelvic limb to this skeleton, and the substance of these remarks with addenda are herewith incorporated.

It is a well-known fact that the proximal extremity of the tibio-tarsal shaft is much larger and more bulky in the young of certain birds than it is in the adults of the same species.

This is very appreciably the case in many Gallinaceous fowls, and I have already remarked upon it as a striking feature in the skeleton of the young of *Centrocercus urophasianus;* while in our present subject, this immature *Geococcyx*, this condition obtains to an extent unequaled, so far as my observations go, by any of the *Gallinæ*.

Further, that portion of the tibio-tarsus, which in the old bird eventually becomes the antero-superior part of the shaft, and supports the pro- and ectocnemial processes, is in the young individual developed as a separate epiphysis. Formerly, from careful examination of material, it appeared to me that this epiphysis was superadded to the true epiphysis of the summit of the shaft of this bone of the leg, and thus corresponded to the olecranon of the ulna. (See

Proc. U. S. Nat. Mus., Vol. vii, 1884, p. 324.) Upon carefully re-examining this material at the present writing it certainly seems that this is the case, but I would prefer to microscopically investigate a series of these bones of all ages and properly stained before restating the opinion.

In *Geococcyx* the proximal end of the tibio-tarsus appears to possess a terminal epiphysis, something similar to what we see in the Frog, and to this is super-added the additional piece, as already stated above; and as age advances in the individual the proximal third of the shaft, so much larger than it actually is in the adult, becomes gradually absorbed so in time to be equal to it in size. (See Pl. I, Fig. 6.) This is very curious. The lower two-thirds of the bone in the young has a calibre proportionately less than the corresponding part in the adult and is in harmony with the size of the bird.

I regret to say that ossification had proceeded so far in this specimen that I was unable to determine anything beyond the single segment at the distal extremity of the bone, and additional material is required for me to decide whether or no the intermedium, as described by Morse, develops in *Geococcyx* as a separate ossicle.

In this young bird the pelvis already exhibits all of those peculiar features, which makes it so interesting a subject for study in the adult, while points of somewhat minor importance are to be noted in other parts of the skeleton. The anterior half of the sternum is quite complete, and all in one piece, while its posterior portion is entirely in cartilage, and as yet gives no hint as to the form it will eventually assume—even the xiphoidal prolongations not being indicated.

On the Osteology of Crotophaga.

Through the courtesy of the U. S. National Museum I have the following osteological material before me to illustrate the skeleton in this extraordinary genus of Cuckoos, representing as they do the subfamily *Crotophaginæ*. First, nearly a complete skeleton of *C. sulcirostris* (No. 6467); the sternum, shoulder-girdle and ribs of a specimen of *C. rugirostris* (No. 7048); finally, the same bones from a skeleton of *C. ani* (No. 432, Bryarth coll.). (See Pl. II, Figs. 8, 9 and 11.)

In some few particulars there is a curious resemblance between the lateral view of the skull of *Crotophaga* and the same view of the

skull of the Common Puffin (*Fratercula*), but upon careful scrutiny we at once see that *Crotophaga* possesses a true cuculine skull, and one that, for at least the posterior moiety of the basal aspect of its cranium, reminds us not a little of Huxley's figure of *Cuculus canorus* (P. Z. S., 1867, p. 444, Fig. 26). Among our Cuckoos, however, *Coccyzus* is the bird that appears to have a skull most like *Cuculus*, and *Crotophaga* upon the lateral view of its skull reminds us of neither of those species.

Regarding the skull of this Ani upon its upper aspect, we are enabled to see how the subcompressed, lofty superior osseous mandible mounds up mesially just in front of the very distinct craniofacial line. The culmen is sharp and arches over handsomely to the tip of the decurved apex of the beak. The small subcircular nostrils can also be partially seen upon this view and the minute foramen that perforates either nasal bone. The large lacrymals have much the form they have in *Geococcyx* and articulate with the surrounding bones in precisely the same manner. Longitudinally, in the middle line, between the orbits, the frontal region exhibits a moderately-raised, rounded eminence, extending backward upon this aspect as far as the vault of the brain-case; and this interorbital space is quite broad in *Crotophaga*—proportionately much more so than it is in *Geococcyx*.

This breadth is likewise enjoyed by the smooth, rounded superficies of the cranial vault.

Laterally this skull presents a well-marked temporal (crotaphyte) fossa; a small post-frontral process directed downward, and a much larger arched squamosal one directed forward and only slightly downward.

The quadrato-jugal bar is straight and slender between quadrate and lacrymal, while the small sesamoid at its posterior end seems to be in a ligament passing from it to the os quadratum.

The capacious orbits are only separated from each other by a thin, incomplete septum, and the foramina in the anterior wall of the brain-case are large and may merge to some extent.

Os quadratum is large, with a good-sized orbital process. Its various projections are thin and compressed, while a deep notch separates its two mandibular facets. Pars plana is also of good size, fusing with the frontal above, where it is pierced internally by a single foramen (two in *Geococcyx*); its infero-external angle being somewhat drawn out into a stumpy apophysis. This osseous

partition aided by the large, descending part of the lacrymal forms a very efficient bulwark between the orbit and the rhinal chamber; while, laterally, in front of the last mentioned bone quite a sizable vacuity exists ere arriving at the posterior edge of the nasal.

The base of this vacuity is spanned by the slender maxillary. Either aural entrance is capacious, and underspanned by a fairly well-developed tympanic bulla. A side of the osseous superior mandible is flat and nearly smooth, being only slightly scarred by delicate vascular venations. Passing next to the base of this skull we find the basitemporal region smooth and rather contracted, the tympanic bulla dipping down considerably below it upon either hand. A pointed bony shield underlaps the anterior entrance to the Eustachian tubes, and the foraminal apertures for the hypoglossal and vagus nerves, and the carotids are very small and inconspicuous. The lower border of the sphenoidal rostrum is narrow and rounded, while either pterygoid is somewhat short, straight and characterized by a raised and sharpened superior border for its anterior two-thirds. These bones articulate far forward from the cranial base, and no sign whatever is seen of basipterygoidal processes.

For their major part the palatines lie in the horizontal plane, they being for their lengths nearly of uniform width, and their postero-external angles are very much and completely rounded off. They are in contact along the middle line next the rostrum but do not seem to fuse together there, and their supero-mesial margins are produced forward into a single and diminutive spicula of bone, which possibly represent the vomer. *Crotophaga* is desmognathous by the fusion of its delicate and spongy maxillo-palatines across the middle line. Indistinguishably fused with these seems to be an osseous septum narium, and the spongy osseous tissue that fills in the hinder moiety of the cavity of the upper mandible. The prepalatine portions of the palatines are in intimate contact with the maxillo-palatines, while anteriorly these horizontal plates become continuous with the flat bony roof of the nether surface of the osseous beak; quite as we fine them in all of our *Cuculidæ*.

With respect to the mandible, we find it of the V-shaped pattern, with a moderately deep symphysis, the latter being concaved above and roundly sharpened along the median line below. The ramal sides are of nearly uniform depth throughout and are by no means narrow; the interangular vacuity behind being small (Pl. II, Fig. 8).

Either articular cup is well concaved, with its inturned process much produced and spine-like. Behind, the process is short and stumpy. Comparatively speaking it is a stronger lower jaw than has either *Geococcyx* or *Coccyzus*.

Typically cuculine, the delicate hyoidean arches of *Crotophaga* present us with little worthy of especial remark. They agree in the main with what was shown to obtain in those parts in the "Road Runner." We must note, however, that in the Ani the ceratohyals are but mere granules of bone that neither fuse with nor meet each other, but simply rest against the anterior tip, on either hand, of the first basibranchial.

I have not examined the sclerotal plates of the eye, nor the intrinsic bones of the ear. They were lost from my specimens.

Beddard has said that

"*Crotophaga ani* is well known to possess a bronchial syrinx, which may be considered as more specialized than that of *Geococcyx* and *Pyrrhocentor*, in that the membrana tympaniformis is limited to the posterior bronchial rings, commencing with about the seventh, and does not extend up to the point of bifurcation of the bronchi; in this respect the syrinx of *Crotophaga* resembles that of *Steatornis*, which has been carefully described by Prof. Garrod." [1]

As in that bird, the bronchi arise from the trachea much as they do in the Mammalia; the first nine rings of each bronchus are entire; the tenth and eleventh rings are considerably wider from side to side, and their extremities are connected by membrane which forms the inner neck of the bronchus; the succeeding rings become gradually narrower and are similarly completed internally by membrane. In *Steatornis* the membrana tympaniformis is only of limited extent, the posterior rings of the bronchi being, like the anterior rings, complete; in *Crotophaga* this is not the case—all the bronchial rings, commencing with the seventh, are semirings; there is a single pair of slender intrinsic muscles attached, one on each side of the tenth bronchial semiring.[2]

As in the case of *Geococcyx*, *Crotophaga* has *eighteen* free vertebræ between the skull and the pelvis, and although these have the same general characters as the corresponding segments in the spinal column of the Ground Cuckoo, they have special features of their own. For instance, the fifth to the eighth cervicals develop a

[1] *Coll. Scientif. Papers*, p. 188.

[2] *P. Z. S.*, 1885, p. 173.

slender osseous bar, on either side, joining the pre- and postzygapophyses, a character that gradually disappears in the next few succeeding vertebræ. Again, we see strong, median hypapophyses in the last cervicals and some of the leading dorsals, and the neural spines to the latter are much as we find them in *Geococcyx* only being one or two more in number. *Crotophaga* seems in the main to agree also in the nature and arrangement of its ribs; they differ, however, in the specimens before me by having a very rudimentary pair on the *twelfth* cervical. There is also a peculiar pair of short, stumpy ribs, detected considerably *backward*, articulating with the first vertebra of the pelvis.

The skeleton of the tail agrees practically with the same part of the bird as we find it in *Geococcyx*, and this remark essentially applies to the pelves of these species of Cuckoos—though in *Crotophaga* the ilia behind do not curl outward quite so much in proportion, and the prepubic spine or process is relatively not so large.

As to their *shoulder-girdles*, *Crotophaga sulcirostris* and *Geococcyx* agree pretty well, though in the former bird we find very notably narrow scapulæ,—long and pointed, while the hypocleidium to the os furcula is relatively as large as we find it in most passerine birds, being curved backward and upward, when the bones are *in situ*, and occupies the lower part of the recess formed by the anterior concaved border of the sternal keel. Os furcula itself is more broadly rounded below than it is in *Geococcyx*. In other species of *Crotophaga* these characters are not quite so strongly marked, approaching, perhaps, more nearly what we see in the Ground Cuckoo.

One would now naturally suppose from the number of points of agreement in the trunk-skeletons of these two species thus far enumerated, that we would surely find their sterna modeled upon the same plan. This, however, is by no means the case, for although *Crotophaga sulcirostris* has essentially a cuculine sternum, with a relatively deeper carina than has *Geococcyx*,[1] it differs radically in the xiphoidal portion of the bone, for it has but one rather shallow notch upon either side; whereas, as we have seen, *Geococcyx* agrees with *Coccyzus* in possessing two. In *Crotophaga ani* this shallow notching of the xiphoidal margin of the sternum

[1] This deeper sternal keel we might naturally expect to find, being a character often seen when we come to compare birds that are by nature flyers, with those that habitually spend the most of their time upon the ground.

is carried to its mininum, and almost entirely disappears, the border of the bone in question well-nigh becoming *entire*.

Being constructed upon exactly the same principle, I find nothing especial requiring description in the pectoral limb of *Crotophaga*, further than what has already been given above for *Geococcyx*. (See Pl. II, Fig. 9.) Practically the characters are the same in all the bones composing the skeleton of this extremity in these two Cuckoos, and I also find that a small os humero-scapulare is present in the *Anis*.

With respect to the pelvic limb, this statement applies with almost equal truth, though in *Crotophaga* the procnemial process of the tibio-tarsus is not as well developed; it has but a *single* tendinal perforation through the hypotarsus of the tarso-metatarsus, and that process is peculiarly capped off by a plate of bone; and, finally, in *Crotophaga* the longitudinal excavation adown the anterior aspect of the tarso-metatarsus is, comparatively speaking, much deeper than it is in *Geococcyx*. Aside from these apparently minor differences the skeletons of the pelvic limbs of these two cuculine types are fundamentally the same.

The Genus Coccyzus Osteologically Considered.

Forms of this group, as *C. americanus*, have a skull, with its associated skeletal parts, very much like *Geococcyx*, and quite different from what we have just described above for *Crotophaga*. (See Pl. II, Fig, 7.) So much is this the case that I will not enter upon a detailed description of the skull of *Coccyzus* but rather give some of the chief departures it makes from the corresponding characters as they occur in that part of the skeleton of the Ground Cuckoo.

In *Coccyzus*, and essentially too in *Centropus* and *Diplopterus*, the structure of all the osseus parts of the superior mandible practically agree, both in form and relations, with what we find in *Geococcyx*. The former species, however, has a relatively shorter and broader bill, but its maxillary processes, at the same time, are not only relatively, but (usually) actually longer than they are in *Geococcyx*.

A lacrymal bone in *Coccyzus* has its descending portion only represented by an outwardly-curved, delicate spicula of bone; the structure as a whole reminding us very much of the lacrymal as we find it in many of our *Tetraonidæ*.

This is by no means the case, however, in *Centropus* and in *Diplopterus nævius*, where in both these genera the lacrymal bones

are, comparatively speaking, large and conspicuous, especially in the last-named species (see Pl. II, Fig. 15).

Posteriorly, the crotophyte fossæ of *Coccyzus* more nearly approach each other than they do in *Geococcyx*, and a pterygoid in the former species develops a raised, thin crest on the superior aspect of its anterior moiety, a character I do not find at all in the Road Runner. These fossæ are very deep in *Centropus superciliosus* and nearly meet behind, while in *Diplopterus nævius* they are shallow and widely separated posteriorly.

Coccyzus may or may not possess a minute spiculiform vomer. I have examined adult fresh specimens to decide this very point, and have found old individuals where this element was undoubtedly missing, while I have found it very feebly developed in others.[1]

Turning next to the remainder of the skeleton we find eighteen free vertebræ between skull and pelvis in the spinal column, as in *Centropus* and *Diplopterus nævius*, and their characters are essentially the same as I have described them for *Geococcyx*. This statement also applies to the caudal vertebræ, but the number and arrangement of the ribs do not either agree with the Ground Cuckoo nor with the Ani.

There are three pairs of free cervical ribs; four pairs of dorsal ribs that connect with the sternum by hæmapophyses; and finally, a pair of pelvic ribs that lack epipleural appendages and whose costal ribs do not quite succeed in reaching the costal border of the sternum. This last pair appear to be absent in *Diplopterus nævius* (Pl. II, Fig. 14).

The pelvis is cuculine in its general character, but differs considerably from the pelvis of *Geococcyx*. Its ilia curl but little over the ilio-ischiac foramen upon either side, and the coalescence between the internal margins of the ilia and the sacral crista is more thorough. The prepubis is very small. In none of the N. American Cuckoos are the parapophyses of the sacral vertebræ opposite the acetabulæ upon the ventral aspects of the pelvis, especially length-

[1] Especial attention is invited to the morphology of the external narial apertures of the superior osseous mandible of *Geococcyx*, *Coccygus*, and *Crotophaga*. In the latter they are clean cut, subcircular, and comparatively small: while in *Geococcyx* and *Coccygus* they are large and subelliptical, but more or less masked by the bony lamina that extends over them, leaving in the case of the first-mentioned species a rather small anterior narial aperture, with usually two apertures in *Coccyzus*, an anterior and a posterior one. They are small and fairly clean cut in *Diplopterus nævius*, but large and triangular in *Centropus*.

ened and strengthened to act as tie-beams to brace the line of pressure between the femora.

In *Centropus superciliosus* the prepubic spines of the pelvis are conspicuously produced, while the postpubic element upon either side extends but very little beyond the bone above it posteriorly. Then in the curious pelvis of this Cuckoo the ilio-neural grooves are very short and are arched over simply by the much antero-posteriorly compressed arches of one of the included vertebræ (Pl. II, Fig. 13). In *Diplopterus nævius* these grooves are open and shallow, while the slender postpubic elements sweep far out behind, and the prepubic spine is barely noticeable. In other words the pelves of these two Cuckoos are essentially very different. *Centropus* has all the main cuculine characters well pronounced, while the pelvis in *Diplopterus* closely resembles that part of the skeleton in some of the passerine birds.

Several interesting points are presented on the part of the bones composing the shoulder-girdle in *Coccyzus*. A scapula is comparatively not quite as long nor as narrow as we find it in *Crotophaga*, and its posterior fourth, in some specimens, is inclined to be broadened, and bent slightly outward. At the sternal end of a coracoid, at its outer side, we meet with a conspicuous, upturned and sharpened process. The hypocleidium of the os furcula of some specimens of *Coccyzus americanus* is of a peculiar form, having a crescentic shape with the concave aspect of the line looking toward the manubrium of the sternum.

Comparatively shorter and broader than we find it in *Geococcyx*, this latter bone nevertheless practically agrees with the sternum of the Ground Cuckoo and with *Diplopterus*.

Its deeper keel has still the true cuculine pattern, and there are two notches upon either side of it, behind, and these are deep in the last named genus. Of the xiphoidal processes thus formed the strong outer pair possess dilated hinder ends, while the weaker inner pair are, upon either side, inclined by their posterior tips toward the postero-external angles of the mid-portion of the xiphoidal prolongation. In some of the Bornean *Meropidæ* these tips fuse at the angular points just mentioned. As in all N. American *Cuculidæ*, the sternum is a very thoroughly pneumatic bone.[1]

[1] A number of the skeletal characters in the case of *Coccyzus* are liable to vary and depart to some extent from the descriptions I am here giving; among which are the depth of the xiphoidal notches; the form of the hypocleidium of

Some points of interest are to be seen in the trachea of *Coccyzus*, for in this Cuckoo, the tracheal rings differ very markedly from what we found to be the case in *Geococcyx*, in that some of them are as fully and completely ossified as are any of the tracheal rings among the *Passeres*. This is likewise the case in *Centropus*. The pessulus also ossifies, as do the arytenoid bones and the thyroid plate.

As for the hyoidean apparatus it seems to agree with the skeleton of it in all ordinary Cuckoos, and practically agrees with the corresponding parts in *Crotophaga*.[1]

No especial nor detailed description is required for the pectoral and pelvic limbs of *Coccyzus*. The skeleton of these parts is cuculine in all particulars, differing but little from what has already been described above for other United States Cuckoos.

In the case of the pelvic limb, this genus of birds agrees with *Crotophaga* in that pro- and ecto-cnemial processes of the tibio-tarsus are quite feebly produced; while, on the other hand, the hypotarsus of the tarso-metatarsus agrees with the corresponding apophysis as we found it in *Geococcyx* in that it exhibits two vertical perforations for the passage of tendons, instead of one, as we found to be the case among the Anis. *Coccyzus* also has the fibula short and weak, and the patella in this Cuckoo is comparatively very small.[2]

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the os furcula; the amount of fusion engaged in between the sacral crista and the internal margins of the ilia, and other points; and this remark applies to a number of other species and genera of the Tree Cuckoos.

[1] This statement must be taken only tentatively, for personally I rely upon Beddard's description of the ossifications of the trachea in *Crotophaga*, and a fuller examination of the trachea in *Coccyzus* may go to show that the parts are more alike in *Coccyzus* and *Geococcyx* than in *Coccyzus* and *Crotophaga*. It is a point that requires more extended examination. In fact all these structures need a much fuller research than they have as yet had bestowed upon them.

[2] Since the above account was written I came across some special notes that I had made and set aside five or six years ago upon the skeleton of *Diplopterus nævius* in the collection of the U. S. National Museum, and although these notes duplicate one or two of the statements already made above, they are sufficiently full in other particulars to warrant their being inserted here as a footnote to render the account of the osteology of that species more complete. They run as follows:

In *Diplopterus nævius* the superior osseous mandible is considerably shorter than the remainder of the skull, measuring from the very distinct cranio-facial line.

Its culmen is rounded and the whole bill decurved, while the external narial

Notes on the Skeleton of a Nestling of Coccyzus americanus.

Allusion has already been made in a former paragraph of this memoir to the material here to be considered. The skeleton I have

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aperture is much as we find it in *Geococcyx*. The frontal region is narrow, concaved, and the cranial vault agrees in form with that region in *Coccyzus*.

The temporal or crotaphyte fossæ, though well marked, are confined to the lateral aspect of the skull. Postfrontal and squamosal processes agree better with what we found in *Crotophaga sulcirostris*, while the quadrate agrees in form with that bone in the average cuculine types. The central portion of the interorbital septum is very deficient in bone, as in the Ground Cuckoos. A pars plana is ample, quadrilateral in outline and exhibits a single nervous foramen above it. The lacrymal practically agrees with that bone as it is seen in *Geococcyx*, as does the quadrato-jugal rod. Turning to the base of the cranium, we find a pterygoid to agree with the corresponding element in *Coccyzus*, with its superior crest still better marked. The palatines, although cuculine in their general features, are peculiar, for their prepalatine portions are markedly narrow, their widest parts being at the middle of the postpalatines, and finally a distinct, spiculiform process of no great length juts out from either postero-external angle.

A rudimentary spine-like vomer may be present. Posteriorly, the backward-extending bulbous ends of the maxillo-palatines are well separated in the median line, and it is only anteriorly that desmognathism is shown by the fusion of these processes with the mass of spongy bone tissue occupying the forepart of the rhinal chambers.

This last seems to be deposited about a true osseous septum narium. Either nasal is perforated by a minute foramen, to which I have invited attention in other Cuckoos and the Kingfishers: internally one of the elements develops an osseous spine that is sent downward and inward toward the maxillo-palatine of the same side. The maxillaries are typically cuculine.

The mandible is V-shaped, decurved, with short symphysis and small ramal vacuity.

Diplopterus nævius has eighteen free vertebræ between skull and pelvis, with the ribs arranged just as we find them in *Geococcyx;* it differs, however, in having six free vertebræ in the skeleton of the tail, with a pygostyle that differs somewhat in form with that bone in both *Coccyzus* and the *Centropodinæ*, in that its postero-superior angle is not drawn upward so as to be rather more prominent than its antero-superior angle—which feature is best seen in *Coccyzus*. The bones of the shoulder-girdle are characteristically cuculine, with the scapulæ long and very narrow, as in *Crotophaga sulcirostris*.

In the form of its sternum it agrees with *Coccyzus americanus*, but shows a few distinctive features in its pelvis, for in *Diplopterus* the ilia anteriorly are more decidedly separated from the sacral crista, and the postpubic elements are well drawn out behind as inturned slender spines, as we see them in many *Passeres*. Otherwise the pelvis of this interesting Cuckoo does not differ so very much from that bone of the skeleton as it occurs in our genus *Coccyzus*.

prepared from the alcoholic specimen exhibits some few points of interest. In the skull I find a nasal bone to have the same form as the nasal of an immature *Geococcyx*, and indeed the entire building up of the skeleton of the head in these two types of Cuckoos seems to be quite similar. With respect to the trachea, my examination of it inclines me to believe that the majority of the rings are entire, especially in the superior half of it. Still more interest attaches to the development of the sternum of this chick of the Yellow-billed Cuckoo, for it, too, ossifies in precisely the same way that that bone does in *Geococcyx*. Its anterior moiety is already in bone, and in one piece only: the posterior part is in cartilage and distinctly shows the xiphoidal notches, two upon either side of the low semi-developed carina. This is very different from what we find in the *Gallinæ*, a group of birds wherein it was shown that the sternum ossifies from several centres, the pieces not fusing together until the bird is nearly a year old.

There are eleven vertebræ in the pelvic sacrum of this young *Coccyzus*, but no special attempt was made to determine how many entered into the formation of the pygostyle. Nor was the microscope brought to bear upon its carpus and tarsus with the view of working out the morphology of the embryological elements that enter into the formation of those two interesting joints in this species.

Synopsis of the Principal Osteological Characters of the Three Subfamilies of the United States Cuculidæ.

Subfamily Crotophaginæ.

Crotophaga ani.

Crotophaga sulcirostris.

1. Superior osseous mandible deep in vertical direction, somewhat compressed transversely; culmen sharp, decidedly curved, mounded in front of transverse line of cranio-facial hinge.

2. External narial apertures small, sharply defined and subcircular in outline.

3. Frontal region broad, convex.

4. Temporal fossæ deeply sculpt; approach moderately behind.

5. Postfrontal process short; squamosal process long. Quadrate large with its processes much compressed. Quadrato-jugal bar

slender. Pars plana large. Interorbital septum thin, large central perforation.

6. Lacrymal large, its descending part lamelliform, broad.

7. Basipterygoid processes completely aborted. Pterygoids straight, moderately long, sharp on superior border.

8. Vomer rudimentary: Palatines plate-like, comparatively broad and placed horizontally, with their postero-external angles completely rounded off. Maxillo-palatines large, spongy, in contact in median line, and with several of the surrounding bones, but not with the vomer.

9. Mandible V-shaped, sides rather deep, ramal vacuity small; angular processes stumpy, with the inturned ones long. Mandibular symphysis less than a third the length of the jaw.

10. Elements of hyoidean arches slender; basibranchials short, separate bones; cerato-hyals very small, not in contact.

11. Eighteen free vertebræ between skull and pelvis; cervical ribs on the twelfth, thirteenth and fourteenth. Four pairs of dorsal ribs, of which the three anterior pairs connect with the sternum. One pair of very short pelvic ribs, directed backward. Pelvis peculiar; anterior ends of ilia dilated, and their inner tips meet the "sacral crista:" posterior to this they are contracted and are not in contact with it. Small prepubic process present, and the ilia, on either side, curl outwardly over the ischiac foramen. Postpubic bones project but very slightly behind. Five caudal vertebræ and a pygostyle; the three last ones of the former having large hypapophyses.

12. Os furcula U-shaped, slender, with large hypocleidium, and articulates with both scapula and coracoid above. Blade of scapula long and narrow. Coracoid long with rather slender shaft.

13. Sternum short, moderately wide, with one pair of rather shallow xiphoidal notches. (These latter are barely noticeable in *C. ani.*) Costal processes conspicuous. Manubrium small. Carina subample, with its border concaved in front, forming a prominent carinal angle. Pneumatic.

14. Humerus longer than either radius or ulna; radial crest short; shaft having the sigmoidal curve. This bone is pneumatic, and the pneumatic fossa is very shallow and the foramen usually single. Radius is straight and slender; the ulna is bowed and stout, and has down its shaft the row of papillæ for the insertion of the quill-butts of the secondary row of feathers. Carpal bones two.

Medius metacarpal well bowed-out from the metacarpal of index digit. Osseous digits long: blade-portion of the proximal phalanx of index digit entire. A notable process at the medio-posterior margin of the medius digit.

15. Bones of pelvic limb long and slender, and apparently non-pneumatic. Femur slightly bowed forward. A small patella present. Fibula feebly developed. Pro- and ecto-cnemial crests of tibio-tarsus somewhat reduced, and the hypo-tarsus of tarso-metatarsus once perforated for tendons, with lateral grooves for the passage of the same. These grooves are formed by the process being capped with a lamina of bone. Anterior aspect of tarso-metatarsus longitudinally grooved for its proximal moiety.

Podal digits run 2, 3, 4, 5, for the 1–4 toes respectively, and the fourth toe is permanently reversed.

Subfamily Centropodinæ.

Geococcyx californianus.

1. Superior osseous mandible not especially deep in vertical direction; comparatively broad at base; culmen broadly rounded, very gently curved; being below the level of the frontal region at the line of the cranio-facial hinge.

2. External narial apertures situated rather far forward, and small only from the fact that the true nostril is permanently and largely sealed over by an osseous lamina continuous with the side of the mandible. Osseous nostril large in nestling.

3. Frontal region only moderately broad, and is concaved.

4. Temporal fossæ well-marked, and well separated behind.

5. Postfrontal and squamosal processes of nearly equal length. Quadrate, quadrato-jugal bar, pars plana and interorbital septum much as in *Crotophaga*. Two foramina for nerves over pars plana, only one in *Crotophaga*.

6. Form of lacrymal a good deal as we find it in the Anis.

7. Basipterygoid processes completely absorbed. Pterygoids as in *Crotophaga* but superior margins not especially sharpened, and with a rudimentary "epipterygoid hook" present.

8. Vomer always present in adult; small, spiculiform, rod-like and free. Palatines agree mainly with *Crotophaga*, but their postero-external angles more abruptly rounded off. Maxillo-palatines as in the Anis.

9. Mandible U-shaped, sides rather shallow; ramal vacuity large; angular processes nearly aborted, with the inturned ones moderately long only. Mandibular symphysis about one-fourth the length of the jaw.

10. Elements of hyoidean arches slender, and practically agree with the corresponding parts in the Anis, but *Geococcyx* has the cerato-hyals more extensively ossified, and fused together anteriorly.

11. Eighteen free vertebræ between skull and pelvis; cervical ribs on the thirteenth and fourteenth. Four pairs of dorsal ribs, of which the three anterior pairs connect with the sternum. Pelvic ribs absent. Pelvis of extraordinary form; very strong and agrees practically with the bone in *Crotophaga*, but the ilia very conspicuously curled outwards behind, and the prepubic process very large.

Skeleton of the tail as in the *Crotophaginæ*.

12. Os furcula moderately U-shaped, somewhat slender; with rather long but narrow hypocleidium. Other bones of this girdle agree in the main with the corresponding ones in our other Cuckoos, but the scapulæ are comparatively not as narrow, and their apices are more rounded posteriorly.

13. Sternum of the same general pattern as in all North American Cuculidæ, but differs from the *Crotophaginæ* in being twice notched upon either side of the keel, which notches are comparatively much deeper, while the carina is relatively shallower. The bone is thoroughly pneumatic.

14. Skeleton of the pectoral limb essentially agrees with what has been recorded above for the *Crotophaginæ*. Osseous papillæ on the shaft of the ulna very prominent. The bowed shaft of the medius metacarpal wide and ribbon-like, slightly twisted upon itself.

15. Bones of pelvic limb long and stout, with the femur pneumatic. Patella, comparatively speaking, rather large. Fibula very feebly developed below the articular ridge on tibio-tarsus. Procnemial crest short and prominent, and the hypotarsus of the tarso-metarsus twice perforated for the passage of tendons. Anterior aspect of tarso-metatarsus, nearly flat for its proximal moiety.

Skeleton of pes essentially agrees with our other *Cuculidæ*.

Subfamily Cuculinæ.

Coccyzus minor.

Coccyzus minor maynardi.

Coccyzus americanus.

Coccyzus americanus occidentalis.

Coccyzus erythropthalmus.

1. Superior osseous mandible but slightly longer than the remainder of the skull. Broad at base, and somewhat compressed vertically; decurved more than in *Geococcyx* and with the culmen similarly rounded.

2. External narial apertures as in *Centropodinæ,* but the overlying lamina not so extensive, and usually leaves *two* openings upon either side of this mandible, one anterior to the other.

3. Frontral region somewhat narrow and concaved.

4. Temporal fossæ broad vertically, somewhat shallow and separated posteriorly only by the rather low supraoccipital prominence.

5. Postfrontal and squamosal processes much reduced. Quadrate as in *Geococcyx*. Quadrato-jugal bar slender. Pars plana essentially agrees with the corresponding part in *Geococcyx*, while the interorbital septum is more nearly entire than it is either in the *Crotophaginæ* or *Centropodinæ.*

6. Lacrymal not large, its descending process rather short, spiculiform, and turned outward. (Reminds us of the lacrymal bone in some of our *Gallinæ*).

7. Basipterygoid processes completely aborted. Pterygoids straight, relatively short, superior border in each raised and sharp.

8. Vomer rudimentary, or may be altogether absent. Palatines as in the *Centropodinæ,* while the maxillo-palatines agree with both the Ground Cuckoos and the Anis.

9. Mandible practically as in *Geococcyx;* sides shallow and the ramal vacuity large.

10. Structurally, the hyoidean apparatus essentially agrees with what we find in *Crotophaga* (but the tracheal ossifications do not seem to correspond in this subfamily with what we find in the *Centropodinæ*).

11. Eighteen free vertebræ between skull and pelvis; cervical ribs on the twelfth, thirteenth and fourteenth. Four pairs of dorsal ribs, all of which connect with the sternum by their hæmapophyses.

One pair of pelvic ribs that do not quite reach the sternum by their costal ribs.

Pelvis not strikingly peculiar, though cuculine in general pattern. Posteriorly, the ilia curl outward only very moderately, and the prepubic processes are quite vestigial in character. (Eleven vertebræ in sacrum of young *Coccyzus*).

Caudal vertebræ and pygostyle agree in the main with N. American *Cuculidæ* generally.

12. Os furcula U-shaped, slender, with luniform hypocleidium of good size. Blade of scapula not strikingly narrow, broadish distally, where it is sharp-pointed and slightly curved outward. A coracoid agrees closely with that bone as it is seen in *Crotophaga*, and in both it develops a conspicuous, upturned process at its sternal end at the outer angle of the dilated portion.

13. General pattern of sternum agrees with *Crotophaga* but the bone has two notches upon either side of the carina, as in the *Centropodinæ*. It differs also from both *Crotophaginæ* and *Centropodinæ* in possessing four facets for costal ribs upon either costal border.

14. Skeleton of pectoral limb cuculine, but possesses an individuality of its own. The humerus is a trifle shorter than either the ulna or radius; the bones of the antibrachium are straighter, especially the ulna, than they are in the other subfamiles. Os humero-scapulare, though small, is usually present in all of our *Cuculidæ*.

15. Bones of pelvic limb long and slender, and apparently nonpnuematic. They have some characters in common with the Anis, and some in common with the Ground Cuckoos. A small patella is present. Fibula feebly developed. Pro- and ecto-cnemial processes of tibio-tarsus reduced, and the hypotarsus of the tarso-metatarsus twice perforated for tendons, with lateral grooves for the passage of the same.

These grooves are formed by the process being capped with a lamina of bone. Anterior aspect of tarso-metatarsus quite flat.

Skeleton of pes upon the same plan as in other *Cuculidæ* characterized above.

Brief Discussion of Cuculine Kinships.

When we come to consider the affinities of the Cuckoos we are confronted with a more or less natural group of birds that have representatives in nearly all parts of the world. They are very different from any of the Suborders thus far treated of by me in

my previous memoirs, and they are to a greater or less extent structurally linked to a variety of other families of birds that have long puzzled both the ornithologist and the avian anatomist. By their zygodactyle feet they may at once be distinguished from any of the enormous group of the *Passeres*, to be considered later on. (The MSS. at this writing are complete.)

Their affinities, if there be any, with the *Caprimulgi*, the *Cypseli*, the *Trogones*, the *Trochili* and the *Pici* must also be quite remote. But this will not apply to the Kingfishers, and much less to certain other groups in various parts of the Old and New World, as the *Musophagidæ*, *Bucconidæ*, *Galbulidæ*, *Meropidæ*, *Momotidæ*, *Bucerotidæ*, *Upupidæ*, *Todidæ*, *Coraciidæ*, *Rhamphastidæ*, *Capitonidæ* and perhaps some few others.

These several families seem to have a Cuckoo vein running all through them, strongly impressed in some cases, barely discernible in others. Indeed, these groups of birds seem to have arisen from some very ancient and once common stock, but by the extinction of numerous related types and groups of types that once filled the now many and various gaps among them, it has left in recent times the most puzzling collection of polymorphic forms that the systematist has to deal with throughout the entire range of ornithology. They have become diversified through all the factors that organic evolution brings to bear upon such plastic organizations as they represent.

In the opinion of a number of authoritative ornithotomists the nearest affines of the *Cuculidæ* are to be seen in the *Musophagidæ*. while the *Meropidæ* are also said to exhibit especially a number of cuculine affinities. Personally, I have never examined the skeleton in any of the *Musophagidæ;* but of certain *Meropidæ* we shall speak a little further along in another memoir now in preparation. One thing must be constantly borne in mind, and that is Cuckoos differ not a little in their osteology among themselves—take *Crotophaga* and *Geococcyx californianus* for instance—so that we meet with certain species of them that in their skeletons offer a greater number of characters that agree with the corresponding characters in forms of other groups than do others of this suborder. Apart from the *Alcyones*, we have in our United States avifauna no very near affines of the *Coccyges*.

Probably the weight of opinion would be thrown in favor of placing the *Cuculidæ* near the *Musophagidæ*, the Plantain-eaters

or Tourocos of Africa. It was Huxley's opinion, Fürbringer thinks so, and Garrod thought so, but we cannot follow the latter in placing the *Cuculidæ* and *Musophagidæ* together in with the Gallinaceous birds!

During the time I have been engaged upon the present memoir, Vols. i and ii of Sharpe's very valuable *Hand-List of Birds* has been presented to me by the trustees of the British Museum, and in the second volume of that work I find the author inserts the Cuckoos in the system in the following manner:[1] The Order COCCYGES (xxxi) is placed between the Order TROGONES (xxx) and the Order SCANSORES (xxxii), and is primarily divided into two sub-orders, namely Sub-Order I, *Musophagi*, and Sub-Order II, *Cuculi*.

The *Musophagi* is made to contain the family *Musophagidæ*, and this latter includes the genera *Turacus* (23 species); *Gallirex* (2 species); *Musophaga* (2 species); *Corythæola* (1 species); *Schizorhis* (5 species); and *Gymnoschizorhis* (2 species). The second sub-order or the CUCULI is made to contain but the single family the *Cuculidæ*, and this is divided into six (6) sub-families thus:

SUB-FAMILIES.	GENERA.	NO. OF SPECIES.
I. CUCULINÆ.	Coccystes	9 species.
	Pachycoccyx	2 "
	Calliechthrus	1 "
	Surniculus	3 "
	Hierrococcyx	7 "
	Cuculus	11 "
	Penthoceryx	1 "
	Cercococcyx	1 "
	Cacomantis	13 "
	Mesocalius	1 "
	Metallococcyx	1 "
	Chrysococcyx	3 "
	Chalcococcyx	15 "
	Heterococcyx	1 "
	Coccyzus	13 "
	Urodynamis	1 "
	Eudynamis	7 "
	Microdynamis	1 "
	Rhamphomantis	1 "
	Scythrops	1 "

[1] R. BOWDLER SHARPE, LL.D.: *A Hand-List of the Genera and Species of Birds*. [Nomenclator Avium tum fossilium tum viventium.] Vols. i, ii. London, 1900.

Sub-Families.	Genera.	No. of Species.
II. Centropodinæ.	Centropus	41 species.
III. Phœnicophainæ.	Saurothera	6 "
	Hyetornis	2 "
	Piaya	7 "
	Zanclostomus	1 "
	Taccocua	1 "
	Rhopodytes	7 "
	Rhinortha	1 "
	Phœnicophaës	1 "
	Rhamphococcyx	2 "
	Rhinococcyx	1 "
	Urococcyx	3 "
	Dryococcyx	1 "
	Ceuthmochares	3 "
	Dasylophus	1 "
	Lepidogrammus	1 "
	Coua	11 "
	Cochlothraustes	1 "
IV. Neomorphinæ.	Carpococcyx	3 "
	Neomorphus	5 "
	Geococcyx	2 "
	Morococcyx	1 "
V. Diplopterinæ.	Diplopterus	1 "
	Dromococcyx	2 "
VI. Crotophaginæ.	Crotophaga	3 "
	Guira	1 "

We therefore find in Sharpe's *Hand-List* that the family *Cuculidæ* is made to contain 45 genera of Cuckoos, and these 45 genera include no less than 161 species. This is a great many different kinds of Cuckoos, and to me it is the most significant index extant, indicating how little, how very little, we yet know of their morphology, and consequently how much guesswork there must essentially be in our attempts to classify them.

The writer is indebted to Mr. Lucas, of the U. S. National Museum, for the loan of a skeleton of a Jacamar (sp. ?), a *Diplopterus*, and a specimen of *Nyctiornis amictus* from Borneo—one of the *Meroptidæ*. All of these I have examined in the present connection and compared them with skeletons of *Ceryle alcyon* and *Ceryle cabanisi*.

Unfortunately the skeleton of *Diplopterus* had been injured, but

a glance at it is sufficient to satisfy us that it stands, in so far as its osteology is concerned, almost directly between the *Centropodinæ* and the *Cuculinæ*. It will be seen from what has been shown above that this is at variance with Dr. Sharpe's opinion.

Beyond what I have hazarded in the concluding paragraphs of this memoir then, in the way of suggestions as to the probable affinity of some of the more typical Cuckoos with other birds, I would not at the present time make or express any more decided opinion. I feel that I ought to command a far wider knowledge of the morphology of the entire group and several of the now-supposed allied groups than I possess at this writing before doing so, or before that opinion would be of any value.

Explanation of Plates.

[All the figures in the Plates are from photographs made direct from the specimens by the author. Figs. 1 to 6 inclusive in Plate I are of natural size, the material being from the author's private collection. The figures of Plate II are all very slightly reduced, and all in the same proportion. The skull shown in Fig. 7 is in the author's cabinets, while all the others belong to the U. S. National Museum.]

Plate I.

Fig. 1. Right lateral view of the skull and lower mandible of *Geococcyx californianus*. Adult.

Fig. 2. Inferior or basal view of the skull of *Geococcyx californianus*. Adult. Different specimen from the one shown in Fig. 1.

Fig. 3. Superior view of the mandible of *Geococcyx californianus*. Adult. Belongs to the skull shown in Fig. 2 of this Plate.

Fig. 4. Ventral aspect of the pelvis of *Geococcyx californianus*. Adult. Belonged to the same individual that furnished the skull shown in Fig. 1 of this Plate. On this pelvis the coccygeal vertebræ and pygostyle are attached *in situ*.

Fig. 5. Superior aspect of the cranium of a subadult specimen of *Geococcyx californianus*, showing principally the frontal and parietal bones with the sutures between them. The bones of the face and other elements have been removed.

Fig. 6. External aspect of the left femur, fibula and tibio-tarsus of a subadult specimen of *Geococcyx californianus*, from the same individual that furnished the skull shown in Fig. 5. The femur is not placed *in situ*, its proximal end is resting on the shaft of the tibio-tarsus, and in this figure we see the epiphysis on the summit of the latter described in the text.

Plate II.

Fig. 7. Right lateral view of the skull and mandible of an adult specimen of the Yellow-billed Cuckoo (*Coccyzus americanus*).

Fig. 8. Right lateral view of the skull and detached mandible of an adult specimen of the Ani (*Crotophaga sulcirostris*). Spec. No. 61467 of the Coll. U. S. Nat. Museum.

fig. 1.

fig. 2.

fig. 3.

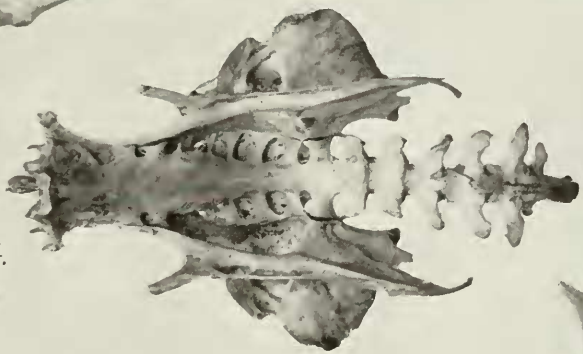

fig. 4.

fig. 5.

fig. 6.

OSTEOLOGY OF GEOCOCCYX CALIFORNIANUS.